2017 Kentucky Statewide Science, Technology and Innovation Plan

April 5, 2018

EXECUTIVE SUMMARY

More than ever, a vibrant economy depends on development of science and innovation capacity. The National Science Foundation's Established Program to Stimulate Competitive Research (NSF EPSCoR) along with other EPSCoR-like programs (e.g., National Aeronautics and Space Administration, NASA, National Institutes of Health, NIH) has been a driving force in developing the science and technology infrastructure (expertise, facilities and talent) within the Commonwealth. This S&I Strategy is broader than NSF EPSCoR to encompass the innovation and commercialization ecology necessary to transform the scientific and technical discoveries into entrepreneurial ventures to develop a forward-looking economy consistent with state strengths. The next generation of scientists and technologists with the expertise to fulfill economic growth expectations through education in the science, technology, engineering, math, and health (STEM) disciplines must be part of this infrastructure capacity development effort.

At this fifth-year anniversary of the implementation of the 2012 Science and Innovation Strategy (S&I Strategy) and as the NSF EPSCoR proposal preparation team begins the process leading to submission for funding, it seemed appropriate to assess progress and evaluate any changes necessary to reflect the current research and development landscape in the Commonwealth as well as the economic landscape. Furthermore, the fact that the 2012 S&I Strategy was developed through a comprehensive year-long process involving a consultant with many stakeholders participating, review of progress is appropriate, keeping in mind that long-term impact of these investment strategies may not be fully realized after only five years. The 2012 S&I Strategy, including appendices, can be found online at http://kstc.org in its entirety. This document will present briefly the progress made under the three priorities identified in the S&I Strategy in terms of legislation, metrics, and return on investment and make any recommendations necessary. The areas of research identified in the S&I Strategy remain the same: 1) agriculture and bioscience, 2) energy and environmental technologies, 3) human health and personalized medicine, 4) information technology and new media, and 5) material science and advanced manufacturing. These areas are in alignment with state priorities but do not offer *apriori* prescriptive research projects as that would thwart the creativity necessary to make transformative advances. The 2012 S&I Strategy was built upon a foundation provided by the original 2000 Kentucky Science and Technology Strategy, many parts of which were enacted into law under the Kentucky Innovation Act and continue to have positive impacts for the development of the Kentucky Science and Technology infrastructure. Where appropriate this assessment will document continued progress from this original statewide strategy.

BACKGROUND

In late 1999, the Kentucky Science and Technology Corporation (KSTC), working in collaboration with the Kentucky Established Program to Stimulate Competitive Research (KY EPSCoR), Kentucky's colleges and universities, state government, and the private sector, completed and issued Kentucky's Science and Technology (S&T) Strategy. That Strategy, embraced by both executive and legislative leaders, became in large part the basis for the design and passage of the 2000 Kentucky Innovation Act (KIA), which laid the foundation for new and important science and technology advancements in Kentucky.

In 2010, KSTC and KY EPSCoR, enlisted the help of Regional Technology Strategies (RST), a nonprofit company located in Chapel Hill, North Carolina to work in concert with existing and new partners to create an updated vision for the state that built on the successes of the 1999 S&T Strategy. This year-long process was informed by documents (Appendices of the 2012 S&I Strategy) produced by groups concerned about the competitiveness of the United States in science and technology, government agencies (e.g., Council on Postsecondary Education, Cabinets, etc.) and the Governor. This five-year assessment is an addendum to this S&I Strategy and does not shift the frame of reference used in its development. This assessment will look at progress toward goals, return on investment and impacts on research, innovation, entrepreneurship and training all relevant to economic growth.

The scope and pace at which new media (e.g., Facebook), SpaceX and other disruptive developments not imagined prior to the 2000 S&T Strategy have emerged and continue to influence the thinking within the 2012 S&I Strategy. Events and progress over the last decade have only further validated the transformative role that science, technology, and innovation are continuing to play in our world. No part of our daily life, from education and work, to play and personal health, are free from the profound influences of these forces. Those who recognize the current science and technology revolution, much like the industrial revolution, is changing the economy and whomever can aggressively take advantage of the opportunities to jump ahead in a transformative way through STEMH research, innovation, and entrepreneurship will be better positioned to gain an economic advantage for the future. This assessment of the 2012 S&I Strategy takes stock of where we are in the Commonwealth.

PRIORITIES

Priority 1: High-Value Research and Development (R&D)

A vibrant R&D capability is essential for building assets of a successful economy and relevant educational programs. Based on extensive review of prior Kentucky R&D strengths and matching these strengths with projected opportunities in R&D identified nationally and globally, the following high-value research areas have been identified:

1. Agriculture and Bioscience,
2. Energy and Environmental Technologies,
3. Human Health and Personalized Medicine,
4. Information Technology and New Media, and
5. Material Science and Advanced Manufacturing

These areas should not be considered silos of activity, rather strengths allowing interconnected multidisciplinary research into unexplored areas. Within these high-value areas, niche research and innovation opportunities have arisen, such as energy storage devices, low Earth orbit space research, and medical and energy nanomaterial applications that are expected to compete for R&D funding. Early entry into new emerging niches enhances the ability to compete for sustained funding support and researchers are encouraged to pursue these opportunities.

Creativity requires less constraints on thinking, thus although these areas are broad, they provide guidance to researchers and innovators without restricting them. The competitive process of peer review of research by a Statewide Committee with an eye to alignment with the S&I Strategy helps keep the focus necessary for the development of critical mass necessary to develop significant research capacity. The following two programs invest in research and development to build high-value research infrastructure.

1. **Kentucky Established Program to Stimulate Competitive Research** (**KY EPSCoR**)

The core mission of the Kentucky EPSCoR Program is to build STEM research infrastructure to enable Kentucky's postsecondary institutions to compete more effectively for federal funding and to advance science and engineering discovery and innovation by leveraging state funds to secure federal funds. It also produces the talent to lead R&D and to generate intellectual property in a fertile ecosystem that attracts, starts, and grows businesses for Kentucky economic development.

The KY EPSCoR Statewide Committee coordinates state investment funds for federal EPSCoR programs including NSF (National Science Foundation), NASA (National Aeronautics and Space Administration), and DOE (Department of Energy). For the first time in recent years, the federal budget also includes DOD (Department of Defense) EPSCoR.

Kentucky EPSCoR has been extremely successful in establishing research and development infrastructure (i.e., facilities, personnel and student training programs) that have made Kentucky more competitive for obtaining additional federal funds.

NSF EPSCoR and state investments helped build nanomaterials laboratories at the University of Louisville and the University of Kentucky that have been invited to be part of the prestigious NSF National Multi-Scale Manufacturing Nano Integration Network along with such prestigious universities, such as Cornell University and Harvard University. Excellence in this area is complementary to the national Lightweight Innovation for Tomorrow program to develop lightweight materials in which the University of Kentucky participates. This area is important for the Automotive industry, a real economic strength in the Commonwealth. The legislature has recognized the automotive industry's importance to the Commonwealth by enacting a legislative caucus to support this initiative and passing a joint resolution recognizing its importance (16 RS HCR 117/GA) for the Commonwealth economy.

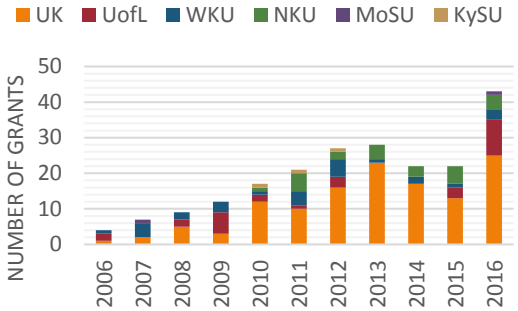
Additionally, NSF offers competitive opportunities such as the EPSCoR Research Infrastructure Improvement Program: Track-2 Focused EPSCoR Collaborations (RII Track-2 FEC) for which proposals must promote collaborations among researchers in EPSCoR jurisdictions and emphasize the recruitment/development of diverse early career faculty and STEM education and workforce development on a defined topic. Recent successful NSF Track-2 awards in Kentucky focus on tools for understanding and modulating the brain (NSF 1539068), development of unmanned aerial systems for atmospheric science and meteorology (NSF 1539070), and successful structures for sustainability of food, energy, and water systems (NSF 1632854).

Aerospace has also been identified as a key sector for the Commonwealth's economy. Aerospace annual exports first topped automotive in 2013 at $5.6 B and currently exceed $10.8 B. The 2017 Aerospace, Aviation and Defense Industry Analysis study identified 630 active companies connected with aerospace and aviation in Kentucky, employing 17,500. NASA EPSCoR has been an important force in the growth of aerospace R&D in the Commonwealth.

Instead of a few large multi-year comprehensive awards integrating higher education research and workforce development, NASA's comparable higher education programs are awarded through separate national competitions for each element. The NASA research and workforce development investments through NASA EPSCoR and NASA Space Grant, with Kentucky EPSCoR state matching, provide seed funding to build expertise and infrastructure in Kentucky, to develop initial results for validation of promising ideas, and to build relationships with NASA researchers. To date, the NASA Kentucky EPSCoR Faculty Travel Opportunity has supported nearly 30 trips connecting researchers from Kentucky institutions with researchers at NASA Centers. The combined success of these catalyzing investments is evidenced (except Sequester years) with the steady increase to tenfold the number of NASA research grants to academic institutions in Kentucky (www.nssc.nasa.gov/grantstatus / by institution), with 67% of these Kentucky PIs having interacted with NASA EPSCoR programs.

Research creates expertise and intellectual property (IP) enabling economic opportunities and development of high-tech start-up businesses. For example, graduate students involved in the 2010-2014 NASA EPSCoR Research Award, "The CubeLab Standard for Improved Access to The International

Space Station for Scientific Payloads," trained graduate and undergraduate students who since founded three start-up companies in Kentucky: Space Tango, Faradine Systems and Mesoloft. Long-term benefits of scientific and technical investments include economic returns



from start-ups, follow-on research competitiveness, and growth of strong, interconnected ecosystems for R&D.

Historically, the Return on Investment (RoI) for each Kentucky dollar invested as required match for federal EPSCoR programs is immediately returned 8.7-fold with the federal awards, and then provides a long-term return of more than 22-to-one because researchers build on the expertise and infrastructure for success in subsequent non-EPSCoR proposals. The annual combined match required for base federal EPSCoR programs (NSF, NASA and DoE combined) is $2M. Following historic returns, this will result each year in more than $17M immediately, and more than $44M long-term research growth for Kentucky.

KIA Program	thru 2011 State $$ Invested	thru 2017 State $$ Invested	Type of Return on Investment	thru 2011 $$ Returned	thru 2017 $$ Returned	thru 2011 ROI State$:Federal$	thru 2017 ROI State$:Federal$
KY EPSCoR	$25,249,541	$51,494,330	Direct Federal Funding	$241,170,000	$466,510,498	$1:$9.5	$1:$8.7
			Follow-on Funding (all sources)	$686,500,000	$1,164,943,914	$1:$27	$1:$22.6

2. **Kentucky Science and Engineering Foundation (KSEF)**

KSEF's primary mission is to build science and engineering capacity through peer-reviewed R&D to shape ideas into innovative emerging products or technologies.

The KSEF has continued to fund emerging ideas and technologies that have been externally reviewed for excellence. These studies are expected to lead to product or technology development that can lead to commercialization. After due diligence, these early stage companies can apply for KEF funding. Again, The KSEF budget continues to decline and has reduced its ability to fund projects deemed outstanding based on external review by experts with great potential for commercialization.

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
KSEF	$16,604,708	$21,182,485	Follow-on Funding Leveraged	$211,000,000	$456,094,645	$1:$13	$1:21.5
			Cash Returns	$127,000	n/a		
			Start-up Companies	40	49		

3. **Kentucky Cyberinfrastructure Development**

Cyberinfrastructure is a collective term encompassing all the components (fiber optics, hardware, software, etc.) needed for a digital-based economy. Some key economic areas and examples in which CI is critical for future Commonwealth advancement are:

- **eHealth:** diagnostic imaging, medical records, medical monitoring, etc.;
- **energy/environment:** smart grids, monitoring systems, etc.;
- **education:** research support, library depositories, education delivery, etc.; and
- **economic development:** high volume global connectivity, redundancy, etc.

Kentucky currently ranks 35th in Broadband connectivity (https://broadbandnow.com/Kentucky). This puts the Commonwealth at a research and economic development disadvantage. Eighty percent of businesses use the internet and require broadband with high speed. Success in research, STEMH education and economic development heavily depend on access to high-speed data communication networks, high performance computing, fast, large-volume data storage and most importantly, professional staff with expertise to help researchers take full advantage of national computing and data resources. NSF continues to express the importance of cyberinfrastructure for R&D excellence.

The Kentucky Wired program was initiated with a $324 million budget financed through bonds. The goal of this project is to provide broadband network service to all state agencies, county courthouses and higher education institutions by 2018. Currently, it is behind schedule and over budget according to Phillip Brown, executive director of the Kentucky Communication Network Authority. This effort needs to be completed to allow universities to be nationally competitive by providing access to massive amounts of data and powerful computational capabilities that will move research and development ahead. Businesses need this network to compete globally and make their companies more efficient and thus successful. The development of a robust cyberinfrastructure is also critical for success in advanced manufacturing (especially the automotive industry), aerospace, medicine and other areas. The Commonwealth is a partner with the Digital Manufacturing Innovation Institute (DMII) headquartered in Illinois through the University of Louisville. This is a multistate effort to streamline manufacturing from

concept to design, to quality control of supply chains, and to manufacturing. Without access to high-speed broadband internet service, the Commonwealth will not be positioned to compete.

Computer science is being emphasized through several programs to train the talent to take full advantage of a high-speed broad band computer network. AdvanceKentucky is a Code.org Professional Learning Partner promoting computer code literacy. Stephen Pruitt, Kentucky Education Commissioner, announced a new computer science initiative that aims to expand students' opportunities in computer science. The initiative is a partnership between the Kentucky Department of Education and AdvanceKentucky.

Priority 2: High Impact Enterprise Development

A strong STEM talent pipeline and a highly competitive research infrastructure focused on high-value R&D is not enough to realize high economic impact. A mentoring and support infrastructure is required to translate research and intellectual property into commercially successful enterprises. The following strategic programs have been identified to support the formation of science and technology-driven companies and the high-value job opportunities they create.

1. **Kentucky Commercialization Fund (KCF)**

KSEF and KCF are aligned to provide a pathway for commercialization of applied research from proof of concept to raising of venture capital. KCF's role along this journey is to support Kentucky universities and colleges in commercializing R&D technologies, products, or processes, and in turn, create new start-ups or enhance opportunities for technology transfer and produce follow-on funding. In FY 16-17 the Commercialization Fund was consolidated with KSEF's Emerging Technologies efforts to support technology commercialization projects within universities prior to the formation of a company. (the program no longer exists: "the intent of the KCF program has been integrated into KSEF's RDE program technology commercialization area")

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
KCF	$5,848,405	$8,305,183	Follow-on Investments	$13,750,000	$95,448,831	$1:$2.4	$1:11.5
			Number of products, Technologies or Processes	n/a	314		
			New Start-ups	n/a	27		

2. **Kentucky Enterprise Fund (KEF)**

KEF exists primarily to encourage the commercialization of innovative ideas and products and the creation of new entrepreneurial companies by providing seed and early-stage capital to small and mid-sized Kentucky firms with high-growth potential.

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
KEF	$31,865,039	$42,754,976	Cash returns	$3,090,000	n/a		
			Follow-on Investments	$542,320,000	n/a	$1:$11.4	n/a
			Company exits	22	54		
			Companies created	100	n/a		

3. **The Kentucky Innovation Network (KyIN)**
(*emerging in 2001 with 6 initial offices, expanding to 13 in 2004 with 12 currently*)

The mission of the KyIN (an outgrowth of KIA) is to help knowledge-based Kentucky companies grow and create higher-paying jobs. The KyIN is administered by the Kentucky Science and Technology Corporation according to an agreement with the Cabinet for Economic Development. The 12 centers in the network, that cover the entire State, work closely with other KIA initiatives, especially KEF. Since inception in 2001: KyIN has assisted 4,148 companies, helped companies raise $1.6 B in funding, and supported or created 13,903 Kentucky Jobs.

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
ICC	$15,968,402	$30,240,000					
			Number of Companies Started		4148		
			Average Salary		$51,233 (2017)		

Activity	FY02-FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
Number of New Companies Assisted	590	129	147	198	240	271	691	809	1,073
Revenues Generated by Innovation Network Companies	$1,110M	$537M	$572M	$458M	$474M	$1.05B	$1.2B	$1.1B	$1.1B
Amount of Company Funds Raised	$299M	$150M	$96M	$127M	$113M	$132M	$190M	$299M	$200M
Number of All New Technology Jobs Supported*	826	443	549	505	580	not tracked			
Number of All New Non-Technology Jobs Supported*	625	163	201	306	494	not tracked			
Number of All New Jobs Supported**	3,384	606	750	811	1,074	1,021	2,040	2,115	2,102
Average Salary of Paid New Technology Jobs Supported	n/a	$66,737	$68,857	$64,662	$64,941	not tracked			
Average Salary of paid New Non-Technology Jobs Supported	n/a	$30,673	$30,809	$31,542	$43,131	not tracked			
Average Salary of All Paid Jobs Created	n/a	$54,666	$57,159	$50,535	$54,909	$57,229	$45,682	$55,936	$51,233
Average Cost of Each Job*	n/a	$3,621	$2,461	$2,422	$2,089	$2,426	$1,668	$1,626	$1,557
Estimated State/Local Income Tax Revenue from New Jobs	$3,989,220	$1,577,659	$2,208,608	$2,146,709	$3,538,336	$3,511,607	$4,070,266	$5,125,219	$4,998,567
Note: n/a - Reporting methods changed year over year such that some metrics were not tracked in previous periods *Includes only full-time, paid positions created in current year as reported by client companies									

4. **Kentucky New Energy Ventures Fund (KNEV)**
   (*created in 2008*)

KNEV (legislatively the Kentucky Alternative Fuels and Renewable Energy Fund) works closely with KEF and the KyIN Network and supports the research, development, and commercialization of alternative fuel and renewable energy products by entrepreneurial companies in Kentucky. Since its inception in 2008, KNEV has supported 27 Kentucky-based energy companies with $4,100,000 in investments alongside private investments in these companies of well over $16,484,000

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
KNEV	$31,190,000	$4,100,000	Follow-on Investment	$16,484,000	n/a	$1:$5.1	n/a
			Number of Companies Helped	27	32		

5. **Kentucky SBIR/STTR Matching Funds Program**
(*created in 2006*)

Created in 2006 by the Kentucky Cabinet for Economic Development (CED)'s Office of Commercialization and Innovation, this program strengthens start-ups and early-stage Kentucky firms by matching their Federal Phase 1 and Phase 2 SBIR and STTR grants. The program helps create and retain high-tech jobs, provides unbroken continuum between SBIR and STTR Phase 1 and Phase 2 funding, makes firms highly competitive to win Federal Phase 2 grants, and serves as a tool that has recruited 55 out-of-state firms to Kentucky.

KIA Program	thru 2011	thru 2017		thru 2011	thru 2017	thru 2011	thru 2017
	State $$ Invested	State $$ Invested	Type of Return on Investment	$$ Returned	$$ Returned	ROI State$:Federal$	ROI State$:Federal$
SBIR/STTR	$26,809,120	$72,202,555	Federal $$ Attained	$46,105,503	$123,388,209	$1:$1.72	$1:$1.71
			Companies Attracted to Kentucky	12	55		
			Existing Kentucky Companies to the Next Level	44	n/a		
			Number of Proposals Phase I and Phase 2 Received	134	366		

Kentucky's SBIR-STTR Matching Funds program is a giant 'next step' to the support provided by KSEF's Phase 0/00 grant programs, which assist Kentucky companies with federal SBIR/STTR Phase 1 and 2 proposal preparation and submission.

6. **Risk Capital Development**

Successful risk capital investment strategies can greatly benefit from novel incentives and long-term thinking. Appropriate legislation that addresses capital issues can lead to more high-paying jobs and innovative companies for the State and help reshape the economic landscape of Kentucky's future. This type of legislation can lay a foundation for Kentucky's next generation to enjoy better jobs and quality of living right here at home.

The Cabinet for Economic Development has established an Angel Investment Tax Credit, up to 50% of their investment, targeting start-up companies in areas related to the high-value research and development areas identified above.

The Commonwealth Seed Capital Fund was established as an independent fund that invests in early-stage Kentucky businesses to facilitate commercialization of innovative ideas and technologies that fall within the target areas of this S&I Strategy.

The Kentucky Enterprise Fund was established by the state to provide a venture capital-like fund that invests ($30,000 to $250,000) in Kentucky-based seed and early stage technology companies in target areas of this S&I Strategy.

The KSEF also supports emerging ideas and technology through a competitive selection process to develop ideas and technologies to a level that can be commercialized.

7. **Develop Innovation and Development of Intellectual Property**

Intellectual Property (IP) is the global currency of innovation. IP protects innovation and invention in the market. Intellectual Property includes, but is not limited to, that which is protectable by statute or legislation such as patents, copyrights, trademarks, service marks, trade secrets, mask works and plant variety protection certificates. Kentucky's research universities are positioned to be a fountainhead for the generation of intellectual property due to their mission of knowledge-based discovery as well as their requirement that affiliated individuals disclose all IP generated under their organization.

The KIN is actively working with chambers of commerce to develop angel investor groups. Also, KSEF has been promoting IP development in coordination with the SBIR/STTR program that encourages Kentucky Companies to seek federal funding to commercialize their IP. It would be very helpful to have a centrally funded team of professionals with patent experience to assist faculty and businesses to write IP, pursue patent searches and file for patent protection. This would achieve economy of scale not possible with distributed models currently in place.

8. **Promote Industry/Academic STEM-related Interactions**

Historically, interactions between the academic sector and industry have been limited. Reasons for infrequent interactions vary but include: lack of time to invest and proprietary knowledge requirements of industry. Activities that encourage and support increased interactions between academia and the private sector should enhance innovation and job creation within the Commonwealth. Moreover, increased partnerships between academia and the private sector is one of the new Broader Impact Review Criterion established in the America Competes Reauthorization Act of 2010 and renewed in 2017. Funding for the following actions will stimulate relationship building between these key economic players.

- Enhance communication via publications, conferences, and webcasts with business sectors about ongoing academic research activities, and the growing strength of the Commonwealth's R&D assets.
    - Enhanced Communication: KY EPSCoR has been developing branding and making efforts to get researchers to recognize and publicize through their public relations offices the support they have been receiving through NSF EPSCoR and NASA EPSCoR. One such effort involved encouraging students participating in Posters-at-the-Capitol, a showcase of student undergraduate research at Commonwealth universities for legislators, to recognize prominently their NSF EPSCoR sponsorship.

- Encourage teaming of innovation-oriented firms with academic research communities to pursue SBIR/STTR and other federal research opportunities.

- Encourage teaming: KSEF has been actively engaged in encouraging companies to partner with SBIR/STTR applications for federal funding to help them commercialize their IP. The KyIN network has also been involved in making businesses aware of academic research activities and encouraging collaboration. NSF and NASA both encourage industry/academic partnerships.

- Establish curriculum feedback opportunities for private sector input into STEM workforce training.
  - Establish curriculum feedback opportunities: The Kentucky Cabinet for Economic Development has implemented workforce programs. One of these programs, Kentucky Federation for Advanced Manufacturing Education (KYFAME) is a partnership between Community Colleges and Industry blending classroom instruction with apprenticeships to meet the greater technical skills required. Many universities have external advisor boards in STEM disciplines comprised of business leaders seeking feedback regarding their curriculum. The programs funded through KIA complement these programs and build the intellectual capital to develop advances in the technologies needed to move these businesses forward and the talent to meet the needs of future employers.

These programs together offer a pathway and support from idea to commercialization leading to start-up companies. More work needs to be done to develop robust venture capital funds and additional tax credits for those investors.

Priority 3: Transformational Talent Development

The most important element of innovation is human talent. A vibrant innovation economy starts in the earliest levels of education when students learn to innovate, think creatively, perform well in STEM subjects, and are exposed to business and entrepreneurship concepts.

1. **AdvanceKentucky Program**

The AdvanceKentucky program has dramatically accelerated high school students' performances in subjects and strategies critical to STEM and innovation by incenting Kentucky's high school students to enroll and excel in Advanced Placement math, science, and English courses.

At its core AdvanceKentucky measures success in terms of numbers of qualifying scores on the rigorous, national AP math, science, and English exams. This involves outreach in an *open enrollment environment* to identify and recruit qualified students into AP MSE classes. This means schools must reach out and "invite" rather than "filter out" more students who traditionally are underrepresented in AP classes, but show promise on various measures. This especially requires more *well-trained teachers* available to teach both AP and Pre-AP MSE classes in this diverse and challenging environment necessary to achieve game-changing progress.

AdvanceKentucky continues to involve more students, including more minority students, in advanced placement (AP) courses in math, science, and English. Data indicate that 78% of students who enroll in AP courses enter college and 43% persist into year 3. These numbers are 90% and 62%, respectively for those students who achieve qualifying scores. Low income students gain the greatest advantage. AdvanceKentucky open enrollment has flipped participation rates in AP courses from 20% in schools who do not participate in AdvanceKentucky to 84% in schools who do participate. This has led to an increase in students who earn a qualifying score. Qualifying scores allow students to CLEP out of certain courses in college thereby giving these students an advantage. This program needs to be further expanded. It demonstrates that Kentucky students are performing at much higher levels of academic rigor.

2. **Governor's Entrepreneurs Program**

A Governor's program focused on entrepreneurship will help prepare participating students to be successful entrepreneurs by exposing them to the mindset, culture, innovative thinking, and skills necessary to start a company. The skill set critical for starting, growing, and sustaining a successful business is often a combination of traits, overlooked in a standard educational setting, such as creative thinking, entrepreneurial leadership skills, risk management, and a willingness to try things and fail and then try something new. Some of the key traits shared by successful entrepreneurs and leaders include a desire to see ideas in action, to solve a problem, and fulfill a need. They must have confidence, optimism, persistence, and a willingness to take chances. Successful entrepreneurs must also be good decision-makers who show flexibility and have a sense of when to change course when something isn't working.

Founded and managed by KSTC since 2013, during the 2016 legislative session the Governor's School for Entrepreneurs was established as a state program administratively attached to Office of the Secretary of the Education and Workforce Cabinet. The Governor's School for Entrepreneurs will be held at Transylvania University in 2017-2018. A three-week summer session is held for a select group of students. These students will turn their bright ideas into real products with the guidance of teachers, college professors, business leaders and other mentors. Beginning July 1, 2016, the Kentucky Entrepreneurship Education Network (KEENStart), a Lexington-based nonprofit, managed the program.

3. **Create the Kentucky Student Capital Fund**

The Fund will build on entrepreneurial education programs within the universities, encourage students to create new products and start-up technology companies, and provide students with the financial and business assistance and resources necessary to build a successful company. The Fund will develop Kentucky's next generation of technology entrepreneurs, provide long-term support to the Commonwealth's innovation economy and lead to the creation of technology jobs.

The Kentucky Science and Technology Corporation has chosen five student-led projects recently to participate in an inaugural FoundersLab business accelerator program. This program takes initial product or concept and helps students create a complete business model around it. The program uses the Lean Start-up approach emphasizing early interaction with customers and other stakeholders to reduce inherent risk associated with start-ups. The broader program STARTUPS@KSTC provides pre-seed and

seed stage funding and other resources for technology-related companies in Kentucky. There are local student innovation centers encouraging students to become entrepreneurial. These could share best practices to improve the student experience and product or concept development. The KIN network welcomes student entrepreneurs and helps them find mentors and other resources to launch their companies.

CONCLUSION AND RECOMMENDATIONS

Research and Development: The purpose of the Science and Innovation Strategy is to outline a pathway by which the Commonwealth can build its science and technology infrastructure and thus capability, translate resulting discoveries into innovations to build the economy and to train the next generation of talent that will be required now and in the future. The three priorities identified, 1) High-value Research and Development, 2) High Impact Enterprise Development and 3) Transformational Talent Development align with this pathway. The Kentucky 2012 Science and Innovation Strategy continued the work of the 2000 Kentucky Science and Technology Strategy, much of which was enacted into law with the Kentucky Innovation Act (KIA).

The Commonwealth has realized great advancement in the science and technology infrastructure and capacity in areas identified in the five research areas that continue to align with its economic strengths. The development of nationally recognized materials, both bio- and nano-materials, research facilities and expertise, important to manufacturing, especially the automobile industry recognized as a top industry by a legislative resolution. Gains in aerospace related research and infrastructure is congruent with the importance of the aerospace industry, again recognized by a joint legislative resolution.

This infrastructure, both in terms of expertise and facilities has made Kentucky more competitive for federal research dollars. KY EPSCoR, (including NSF, NIH IDeA, NASA, DoE, and DoD) and KSEF programs have leveraged state dollars effectively in building research and development capacity required to be competitive for research dollars and in the future economy. Innovations developed through this research have been transferred to entrepreneurship and commercialization support agencies identified in the High Impact Enterprise Development section. Programs supporting the development of enhanced research and development capacity have recently been jeopardized by budget cuts to the point where the Commonwealth may not be able to meet its match requirement for obtaining federal dollars through these programs. The state needs to continue to build on the current momentum if possible. The budget request to simply meet matching obligations that help leverage state dollars to obtain federal dollars for programs identified under the High-value Research and Development Section is $6,402,000 for these programs. It is understood, that there are no guarantees of state funding beyond the amounts provided within the state's annual budgets.

Efforts to develop a cyberinfrastructure should be continued to completion. A robust cyberinfrastructure is critical for science and technology research and development and for start-up companies and existing companies. The economy is global and connectivity is essential to compete.

KIA Program	State Funding			ROI Federal $$ for each State $	Budget needed to achieve full capacity
	FY14/15	FY15/16	FY16/17		
EPSCoR	$1,370,900	$1,370,900	$1,288,800	$22.60	$2,565,000
KSEF	$1,087,900	$1,087,900	n/a	$21.50	n/a
KSEF & KCF	n/a	n/a	$1,407,000	n/a	$2,565,000

Enterprise Development: Building an innovation and commercialization ecosystem is complicated and requires investments at several stages. The Commonwealth has made great progress via several programs that interact in this regard. KSEF Identifies new innovations and works with KCF, KEF, KNEV and the KIN to identify and provide seed funding and mentorship to develop innovations into commercial products or processes creating start-up companies. These efforts have been aided by angel investor tax credits and the SBIR/STTR programs. The growth of these efforts and identification of more investment capital is important for Kentucky to transform its economy through entrepreneurship and high-tech start-up companies. Evidence that these efforts are working is the recognition by the Kaufman Foundation that Kentucky is rising to the top in entrepreneurship. These programs need to be continued and investment capital sources expanded.

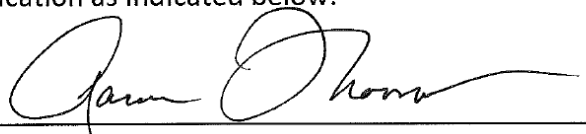
KIA Program	State Funding			ROI Federal $$ for each State $	Budget needed to achieve full capacity
	FY14/15	FY15/16	FY16/17		
KCF[1]	$407,900	$407,900	$0[1]	$11.50	n/a
KEF	$2,193,800	$2,193,800	$2,062,500	n/a	$4,000,000
KNEV	$66,363	$70,500	$602,964	$5.10	n/a
[1]KCF merged with KEF FY16/17					

Talent Development: An essential component to developing the economy through research and development and enterprise development is the talent capable of meeting the needs of this economy and creating new innovations in this rapidly changing world. The AdvanceKentucky Program, initiated through a grant, has demonstrated that by challenging students in the STEM disciplines that they can achieve at high levels. At a time when other countries, such as China, are investing in training students in the STEM areas, the Commonwealth needs to play its part in making the U.S. competitive in the future. The Governor's Entrepreneurship Program is encouraging students to think entrepreneurially and giving them the skills create companies. These efforts should be expanded.

Program	State Funding			ROI Federal $$ for each State $	Budget needed to achieve full capacity
	FY14/15	FY15/16	FY16/17		
AdvanceKentucky	$2,050,000[2]	$2,450,000[2]	$1,700,000	$11.50	n/a
Governor's School for Entrepreneurs	$240,000	$200,000	$200,200[3]	n/a	$4,000,000
KNEV	$66,363	$70,500	$602,964	$5.10	n/a
[2]Includes $750,000/yr Race to the Top federal funding pass-thru by KDE (ended in FY 15/16)					
[3]Governor's School for Entrepreneurs no longer managed by KSTC after FY15/16					

---------- End of Assessment----------

This 2017 Five-year Progress Report has been reviewed by the Kentucky Council on Postsecondary Education as indicated below:



Aaron Thompson, Executive Vice President and Chief Academic Officer
Kentucky Council on Postsecondary Education

04-20-2018
Date